Coding and decoding method and device

FIELD OF THE INVENTION

The present invention generally relates to video compression and, more particularly, to a method of coding an input digital video sequence corresponding to an original color image sequence, said method comprising at least the following steps :

5   (1)   a converting step, provided for converting said video sequence from the original spatial representation domain to less representation data (for example, such as used in transform coding, mesh-based coding, predictive coding, etc...) ;

(2)   a quantization step, provided for transforming the converted signals thus obtained into a reduced set of data ;

10   (3)   an encoding step, provided for coding said reduced set of data.

The invention also relates to a corresponding encoder, to a method of decoding signals coded by means of said coding method, to a corresponding decoder, and to systems comprising computer readable program codes for implementing said coding and decoding methods.

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BACKGROUND OF THE INVENTION

Data compression systems generally operate on an original data stream by exploiting the redundancies in the data, in order to reduce the size of said data to a compressed format more adapted to a transmission or storing operation. For these data,

20   several color spaces may be used (a color space is completely parametrized with three colors linearly independent), and for instance the red-green-blue (RGB) color space (which is still severely redundant) or the so-called opponent color space, nominally white/black (or WB), red/green (or RG) and blue/yellow (or BY), or, in the video case, the YUV space.

In classical video approaches, the video is often encoded along the three

25   following separate channels : luminance Y, component U of chrominance, component V of chrominance. As it seems difficult, with this classical (Y, U, V) representation scheme, to highly improve the rate/distorsion ratio, it has been proposed in the european patent application n° 02290484.1 filed on February 28, 2002, by the applicant (PHFR020014) to change the representation space in order to achieve a higher coding efficiency (for example in

order to encode more information with the same bit budget, or less information with far less
bits). The coding method described in said document mainly comprises, before the coding
step, a pre-processing step, provided for verifying in which color space the input video
sequence is and transforming said space into a less redundant one by means of a non linear

5   transformation. However, less information may lead to a lower quality.

SUMMARY OF THE INVENTION
          It is therefore a first object of the invention to propose another encoding
method for the compression of a digital color video sequence, allowing to transform the

10   original color space of said sequence into a less redundant one, by means of a non-linear
transformation taking into account the possible lower quality finally obtained.
          To this end, the invention relates to a coding method such as defined in the
introductory part of the description and which is moreover characterized in that it also
comprises, before said converting step, a pre-processing step, provided for determining if the

15   color space of the input video sequence is the YUV color space, where Y is the luminance
component and U, V the chrominance components, and transforming said YUV color space
into a less redundant color space by means of a non-linear transformation taking into account
the possible lower quality finally obtained.
          By coding with a greater precision all the relevant part of the information,

20   whereas non-relevant information may be degraded, a better coding efficiency is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS
          The invention will now be described in a more detailed manner, with reference
to the accompanying drawings in which :

25   Fig.1 illustrates an uniform luminance dynamic compression (the X-axis
corresponds to the original luminance values and the Y-axis to the new ones, as obtained
after compression);
          Fig.2 illustrates an example of perceptual dynamic compression according to
the invention, with similar axes ;

30   Fig.3 illustrates the case of different ratios for the luminance compression,
according to the concerned range ;
          Fig.4 illustrates the case of an adaptive and piecewise continuous compression
for the side ranges ;
          Fig.5 illustrates how the original luminance values can be clustered outside the

central range ;

Figs.6 and 7 depict respectively a coding device and decoding device according to the invention.

5   DETAILED DESCRIPTION OF THE INVENTION

Considering that, for a wide range of applications (such as digital movies, high-definition television, transmission or visualization of scientific imagery,...), the ultimate consumer is the human eye, the basic idea of the invention consists in choosing a representation based upon the partition of the visual signals by the early human visual

10   system, i.e. in designing the image codes in such a way that they match the visual capacities of the human observer.

Perceptual studies have already shown that, under standard viewing conditions, human eyes cannot distinguish small luminance variations (from 1 to 5 grey levels). A common approach has then consisted in uniformly compressing the luminance

15   dynamic by using less grey levels, which is for instance illustrated in Fig.1 where 128 luminance grey levels are used instead of 256 ones (which is equivalent to a 7 bits luminance coding). Tests have shown that, if this luminance dynamic compression followed by the inverse transform are applied to an image, human eyes cannot detect any variation between the original image and the reconstructed one.

20   According to the invention, it is then proposed to adaptively compress the luminance dynamic. Perceptual tests performed by the applicant show that, for a luminance dynamic including 256 grey levels (from 0 to 255 for example), human eyes are more sensitive to luminance changes inside the luminance range [70 ; 130] than in the range [0 ; 70] or in the range [130 ; 255]. More generally, the applicant has considered that, for a

25   luminance dynamic including N grey levels (from 0 to N-1 for example), a more relevant information is the one located in a central range [A ; B] and a less relevant information is located in the side ranges [0 ; A] and [B ; N-1].

In order to exploit this property of a variable perception according to the considered luminance ranges, it is then proposed, given an original luminance range of N

30   grey levels (for example from 0 to N-1 as illustrated in Fig.2) and, according to the uniform luminance dynamic compression illustrated in Fig.1, a corresponding output luminance range of M grey levels (for example from 0 to M-1 as shown in Fig.2), with M lower than N, to keep unchanged the luminance dynamic inside the central range

[A ; B] and to compress the luminance outside said central range, as shown in Fig.2. As seen above, tests performed by the applicant show that A = 70 and B = 130 are the values preferably chosen (for N = 256). For instance, in the example illustrated in Fig.3, the luminance dynamic is kept unchanged between 70 and 130, whereas a compression ratio of 2

5   is used outside this range, between 0 and 70 and between 130 and 255.

Practically, several compression modes may be proposed. In the example of Fig.2, the compression in the side ranges is uniform, but other solutions are possible. As illustrated in Fig.4, the compression may also be adaptive and piecewise continuous outside the central range. In this manner, the luminance compression is progressively lessened from 0

10   to A and from N-1 to B. For instance, simple affine functions (three in Fig.4) may be used, but also more complex functions (such as sigmoid functions) are possible. An alternative solution may be to use different ratios for the values in the central range and the values outside it. For example, a ratio of 2 may be used in the central range [70,130] and a higher ratio in the side ranges [0,70] and [130,255], for a compression from 256 grey levels to 64

15   ones (i.e with 6 bits).

It may also be noticed that, because only M integer values are used after the dynamic compression, once the luminance transformation is performed, more precise values are used for original values inside the central range (between A and B), whereas outside said central range many original values are clustered (as depicted in Fig.5) in a single one (and

20   clustered values can in turn be clustered in order to further increase the dynamic compression in anyone of the side ranges, or both).

An embodiment of a coding device for the implementation of the coding method according to the invention is now described. As shown in Fig.6, the video sequence (video signal VS) is first presented to a preprocessor 61, the output of which is received by an

25   encoder 62. The data contained in the input video signal include pixel values which describe the color components (luminance signal Y, color difference signals U and V) of a corresponding location in the original images to which the video sequence corresponds. The encoder 62 comprises for instance a DCT (discrete cosine transform) transform circuit 161, which linearly transforms blocks of 8 x 8 pixels into the frequency domain, a quantizer 162,

30   that receives the DCT coefficients thus obtained and performs their quantization, a variable length coder 163, that carries out the coding step of the quantized coefficients, and a rate controller 164, that stores the output signal of the coder 163 and sends to the quantizer 162 a feedback signal allowing to modify the quantization setting (such a rate controller generally comprises a buffer for receiving the coded bitstream and an update circuit for generating an

updated quantization setting). The preprocessor 61 is provided for changing the representation space (Y, U, V) into the new space.

At the decoding side, a decoding device is provided for implementing the above-mentioned inverse transformation and comprises, as shown in Fig.7, a decoder 71 followed by a postprocessor 72 carrying out the inverse transformation allowing to recover the true color image CI. Said decoder, that receives the bitstream coded by means of the coding device described above, usually comprises a variable length decoder 171, an inverse quantization circuit 172, an inverse DCT circuit 173, and a reconstruction circuit 174.

The encoding and decoding devices, (61, 62) and (71, 72) respectively, can be implemented in a variety of ways to perform the functionalities described herein. In one embodiment, they may be embodied as software stored on media and executed by a general purpose or specifically configured computer system, typically including a central processing unit, memory and one or more input/output devices and processors. Alternatively, they may be implemented as a combination of hardware, software or firmware, without excluding that a single item of hardware or software can carry out several functions or that an assembly of items of hardware or software or both carry out a single function. The described methods and devices may be implemented by any type of computer system or other apparatus adapted for carrying out the methods described herein, this computer system including a computer program that, when loaded and executed, controls the computer system such that it carries out the methods described herein.

Alternatively, a specific use computer, containing specialized hardware for carrying out one or more of the functional tasks of the invention, can be utilized. The present invention can also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods and functions described herein, and which – when loaded in a computer system - is able to carry out these methods and functions. Computer program, software program, program, program product, or software, in the present context mean any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following : (a) conversion to another language, code or notation ; and/or (b) reproduction in a different material form.